

Automobile-integrated and networked computer

Stevens Institute of Technology
Engineering Design VI- EE/CPE 322

HW 4

I pledge my honor that I have abided by the Stevens Honor System.

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Summary of assignments of individual group members

- Rajwinder Singh researched and referenced similar projects regarding integrating a computer and a car together.
- Matthew Conforth researched car to mobile device communication interfaces, car to home communication interface and file transfer protocols to connect with a home server.
- Anirudh Agarwal researched and referenced similar projects regarding integrating a computer and a car together.
- Imrul Sumit researched sensors implemented in modern cars and the relation to the car's main control unit (ECU) and telemetry implementations to log data from wireless sensor systems.
- Joseph Salomon researched uses of flash drives running light weight operating systems designed specifically for turning general-purpose PCs into network appliances.

Sensors (Car Health)

A) ECU

The engine control unit (ECU) is a computer inside most cars that determine the amount of fuel, ignition timing and other parameters by monitoring the engine through sensors. "The ECU uses closed-loop control, a control scheme that monitors outputs of a system to control the inputs to a system, managing the emissions and fuel economy of the engine (as well as a host of other parameters)." ¹ Typically the ECU will have an array of sensors, including crank angle sensor, an O₂ sensor, a throttle position sensor/TPS, engine temperature sensor, air induction valve, exhaust gas recirculation valves.

"The ECU may also be connected to other systems which may be present on modern cars, such as an air bypass to increase idle speed while warming up, a system to adjust the opening of the butterfly valve controlling the intake airflow, a vehicle speed sensor, exhaust gas temperature sensor, and others." ²

By connecting the ECU to a computer on board the car, the car's health could be actively monitored from incoming data. Usually the ECU triggers the check engine signals should there be anything wrong and a mechanic could extract the specific information from the ECU to determine the cause. The computer onboard could be set to update as frequently as desired so that problems could be anticipated by the end user before immediate action would be required.

There are also different sensors to analyze structural damages. The company Acellent has a product that could be used with this project (though costly).

"Acellent's technology, which consists of a thin dielectric film embedded with a network of sensors, monitors structures for misuse, damage, impact, or fatigue. The monitoring layer can either be surface-mounted or embedded into the structure during fabrication.

¹ Karim Nice. "How Car Computers Work". April 11, 2001 <http://auto.howstuffworks.com/car-computer.htm> (March 03, 2007)

² http://everything2.com/index.pl?node_id=1383402

The system would automatically instruct actuators to generate pre-selected diagnostic signals and transmit them to neighboring sensors whose response could then be interpreted in terms of structural changes due to external loads, structural damage or changes in material properties.”³

The maintenance of the structural integrity of the car could be achieved through strain gauges and fiber optics to measure damage/fatigue to car chassis.

B) Telemetry

A telemetry system could also be used for real time wireless data acquisition from different sensors. “A telemetry transmitter consists of a set of measuring instruments, an encoder that translates instrument readings into analog or digital signals, a modulator, and a wireless transmitter with an antenna. A telemetry receiver consists of an antenna, a set of radio-frequency (RF) amplifiers, a demodulator, and recording devices.”⁴

Sample implementation with sensors and telemetry:

www1.cs.columbia.edu/~sedwards/classes/2004/4840/proposals/daq-t.pdf
http://instruct1.cit.cornell.edu/courses/ee476/FinalProjects/s2005/mpd25_y1293/476FinPrj/INDEX.HTM

Communications

A) Car-Mobile Device Communication Interface

Bluetooth is an industrial specification for wireless personal area networks (PANs). Bluetooth provides a way to connect and exchange information between devices such as mobile phones, laptops, PCs, printers, digital cameras and video game consoles over a secure, globally unlicensed short-range radio frequency. The Bluetooth specifications are developed and licensed by the Bluetooth Special Interest Group. Bluetooth is a radio standard and communications protocol primarily designed for low power consumption, with a short range (power-class-dependent: 1 metre, 10 metres, 100 metres) based on low-cost transceiver microchips in each device.

Bluetooth uses the 2.45 GHz Industrial, Scientific, Medical (ISM) Band. This is an internationally unregistered band and, as such, is utilized by a lot of technologies: microwave ovens, 802.11b and 802.11g wireless networking, and some wireless phones. To reduce interference caused by Bluetooth devices, the transceivers only output 1 mW signals. To counter interference from other devices, Bluetooth divides the band into seventy-nine channels. Devices randomly "hop" through these seventy-nine channels up to 1600 times per second, so that any interference from another, wireless device is limited to a tiny fraction of a second. This is coupled with error-correcting software to counter even these tiny interruptions. When two Bluetooth devices link up they hop through the channels in sequence. Bluetooth devices must be “paired” to facilitate communication.

B) Car-Home Communication Interface (802.11g)

³ <http://www.mdatechnology.net/techsearch.asp?articleid=675>

⁴ http://whatis.techtarget.com/definition/0,,sid9_gci821067,00.html

The 802.11g standard uses the 2.40 GHz band, operating in the United States under Part 15 of the FCC Rules and Regulations. It operates at a maximum raw data rate of 54 Mbit/s, or about 24.7 Mbit/s net throughput. 802.11g hardware is compatible with 802.11b hardware. The modulation scheme used in 802.11g is orthogonal frequency-division multiplexing (OFDM) for the data rates of 6, 9, 12, 18, 24, 36, 48, and 54 Mbit/s. At low bandwidth, it reverts to the 802.11b standard CCK for 5.5 and 11 Mbit/s and DBPSK/DQPSK+DSSS for 1 and 2 Mbit/s. Even though 802.11g operates in the same frequency band as 802.11b, it can achieve higher data rates because of its similarities to 802.11a. The maximum range of 802.11g devices is slightly greater than that of 802.11b devices, but the range in which a client can achieve the full 54 Mbit/s data rate is much shorter than that of which a 802.11b client can reach 11 Mbit/s.

C) File Transfer Protocols

To actually move data files with the wireless interface, it is necessary to implement file transfer protocols. To support a wide variety of users, the project will support two different protocols: CIFS and FTP.

Common Internet File System Protocol (CIFS) is the standard network file transfer protocol in the Microsoft Windows family of operating systems. As a result of Microsoft's enormous consumer market share, CIFS has become popular across a variety of platforms. CIFS support will make it very easy for typical users to move files between their PC/laptop and car.

Client systems use the CIFS protocol to request file and print services from server systems over a network. It is based on the Server Message Block (SMB) protocol. Several dialects of the SMB protocol are in use by a variety of servers with differing capabilities. A CIFS client determines an acceptable dialect to use, and the capabilities of a server, when it first negotiates a session with the server.

Supported file access operations include open, close, read, write, and seek. CIFS supports unicode file names, extended attributes, file and record locking, safe caching, read-ahead and write-behind, file change notification, protocol version negotiation, distributed replicated virtual volumes, server name resolution independence, and batched requests.

File Transfer Protocol (FTP) is an old but very common network file transfer protocol. This would be an alternative to CIFS to increase the supported user base of the project. Virtually any device that supports TCP/IP networking has FTP support.

There are two computers involved in an FTP transfer: a server and a client. The FTP server, running FTP server software, listens on the network for connection requests from other computers. The client computer, running FTP client software, initiates a connection to the server. Once connected, the client can do a number of file manipulation operations such as uploading files to the server, download files from the server, rename or delete files on the server and so on. Any software company or individual programmer is able to create FTP server or client software because the protocol is an open standard. Virtually every computer platform supports the FTP

protocol. This allows any computer connected to a TCP/IP based network to manipulate files on another computer on that network regardless of which operating systems are involved. FTP runs exclusively over TCP. FTP servers by default listen on port 21 for incoming connections from FTP clients. A connection to this port from the FTP Client forms the control stream on which commands are passed to the FTP server from the FTP client and on occasion from the FTP server to the FTP client. For the actual file transfer to take place, a different connection is required which is called the data stream.

Flash Drives

“A flash drive , related to a solid state drive, is a storage device that uses flash memory rather than conventional spinning platters to store data. Unlike a USB flash drive or keydrive, flash drives tend to physically imitate conventional hard drives in size, shape, and interface so that they may act as a replacement for hard drives.

These products are typically used as low power, rugged replacements for hard drives, especially in installations exposed to extreme conditions. The flash memory cells tend to fail after around a million writes which made early devices unsuitable for storage which is often updated in place, such as swap files. To address this problem, some flash disk vendors have introduced wear-levelling techniques that track usage and transparently relocate the data in highly utilized extents of storage to extents that have been less utilized. Unlike solid state disks, flash drives do not generally require backup battery systems.

Another use for flash drives is running light weight operating systems designed specifically for turning general-purpose PCs into network appliances comparable to more expensive routers and firewalls. In this situation, a write protected flash drive containing the whole operating system is used to boot the system. A similar system could boot from CD, floppy disk or a traditional hard drive but flash memory is a good choice because of very low power consumption and failure rate.”

1500G, 0.5ms operating shock
16.3G operating random vibration
Full -40°C to +85°C industrial temperature range

SWOT

Strength

This project will include many positive points. One main point of this project is that this kind of project has not been done before. There are so many people in the US alone who love computers and entertainment. Successfully completing this project will result in a computer that will let people receive their favorite music and videos in their car from a home computer. People will also be able to check there email in the morning while their car is warming up. Another strength of this project would be that it will come in a complete package including navigation system, car monitoring system and the wireless card to connect to WAN and LAN.

Weakness

Along all the positive strength, this project will include some weakness as well. Some of the weakness will include:

- Project might get very expensive due to critical parts such as touch screen computer, GPS chip and Bluetooth, sensors.
- Assembling all the parts inside the car with the retractable monitor will be a challenge.
- Implementing sensor systems by telemetry (similar to champ cars) would be very costly while the alternative is finding a modern car with available sensors. The car might suffer damage because of the testing of code that is required

Opportunities

This project will offer many opportunities if the group can complete it in well manner. One can offer to sell this computer to different car companies if they are interested. Another way to sell this computer would be to offer to a third party firm such as Pioneer, Sony or some other companies who work on car stereos and navigation systems. Interfacing with the ECU will be a great option to give users who want to maintain care of their vehicle more actively.

Threats

The biggest threat to this project would be the latest technology from the car companies. Car companies these days are coming with the newest technology in their cars. This project might get outdated if a car company starts offering a similar computer inside their cars before the completion of this project. Most companies already have sensors that look for problems more passively. Consumers might not like the extra hassle of more technical aspects to care for which reduces the market the project will appeal to.

References

Car sensor and ECU

- Karim Nice. *"How Car Computers Work"*. April 11, 2001
<http://auto.howstuffworks.com/car-computer.htm> (March 03, 2007)
- Marshall Brain. *"How Champ Cars Work"*. June 02, 2000
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Sample implementation with sensors and telemetry:

- www1.cs.columbia.edu/~sedwards/classes/2004/4840/proposals/daq-t.pdf
- http://instruct1.cit.cornell.edu/courses/ee476/FinalProjects/s2005/mpd25_y1293/476FinPrj/INDEX.HTM
- <http://www.mdatechnology.net/techsearch.asp?articleid=675>
(Sensor for analyzing structural integrity of car)

Car-Mobile Device Communication Interface

- <http://www.bluetooth.com/Bluetooth/Learn/Technology/Specifications/>
- <http://www.howstuffworks.com/bluetooth.htm>
- <http://en.wikipedia.org/wiki/Bluetooth>
- <http://people.csail.mit.edu/albert/bluez-intro/>
- <http://www.cs.utk.edu/~dasgupta/bluetooth/>
- <http://ispedia.terry.uga.edu/index.php/Bluetooth>
- <http://www.macros.utah.edu/documentation/hardware/bluetooth.html>

Car-Home Communication Interface (802.11g)

- <http://standards.ieee.org/getieee802/802.11.html>
- <http://www.eecs.berkeley.edu/~ergen/docs/IEEE-802.11overview.ppt>
- <http://www.oreillynet.com/wireless/2005/05/20/graphics/802.11Poster.pdf>
- <http://technet2.microsoft.com/WindowsServer/en/library/370b019f-711f-4d5a-8b1e-4289db0bcafd1033.mspx?mfr=true>

CIFS and FTP

- <http://msdn.microsoft.com/library/default.asp?url=/library/en-us/cifs/protocol/cifs.asp>
- <http://www.microsoft.com/mind/1196/cifs.asp>
- <http://tools.ietf.org/html/draft-leach-cifs-v1-spec-01>
- <http://ubiqx.org/cifs/SMB.html>

- <http://www.microsoft.com/downloads/details.aspx?FamilyID=c4adb584-7ff0-4acf-bd91-5f7708adb23c&displaylang=en>
- <http://en.wikipedia.org/wiki/Ftp>
- <http://tools.ietf.org/html/rfc959>
- <http://tools.ietf.org/html/rfc1579>
- <http://www.nsftools.com/tips/RawFTP.htm>
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- http://www.ncftp.com/libncftp/doc/ftp_overview.html